HEDL-SA-1735-FP

CONF-790816--71

SAFETY ANALYSIS OF EXPERIMENTS PROPOSED FOR IRRADIATION IN FFTF

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January, 1979

Paper for presentation at the
International Meeting on
Fast Reactor Safety Technology
August 19-23, 1979
Seattle, Washington

HANFORD ENGINEERING DEVELOPMENT LABORATORY
Operated by Westinghouse Hanford Company, a subsidiary of Westinghouse Electric Corporation, under the Department of Energy Contract No. EY-76-C-14-2170

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ABSTRACT

SAFETY ANALYSIS OF EXPERIMENTS PROPOSED FOR IRRADIATION IN FFTF

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A safety analysis of all experiments to be irradiated in FFTF is required to demonstrate that the experiment does not constitute a hazard to the reactor or the public. This paper summarizes the review procedure, the scope of the analysis and safety acceptance criteria.

The FTR is designed to irradiate fuels and structural materials in an environment prototypical of large LMFBRs. A variety of concepts have been suggested as possible fuels and structural materials for breeder reactors so it is desirable to achieve flexibility in establishing acceptance criteria for tests. A safety review of each test is required in order to protect the reactor and the public from any consequences of an experiment failure. This paper describes the review procedure and discusses the scope and the acceptance criteria for safety analyses of experiments. The safety requirements are intended to be consistent with ANSI N401-1974, "Review of Experiments for Research Reactors."

The general criteria for test acceptability are as follows:

- The test loading must be in compliance with the FFTF Plant Technical Specifications.

- Each test must be capable of responding to FFTF design transients without increasing the severity of thermal transients on plant components. Proposed exceptions must be supported by stress analyses.

- Each test must be capable of withstanding design transients without exceeding safety limits established and justified for each test.

- Each test must be capable of accommodating internal failure without propagation of damage beyond the test boundary.

- The test loading must not increase the potential for a hypothetical core disruptive accident (HCDA) nor increase the potential energetics and post-accident heat removal (PAHR) requirements of an HCDA beyond the established envelope of plant capability.

The experiment review process consists of the following main elements:

1. Review for technical feasibility

2. Review of the Test Design Description (TDD) Volumes 1A and 1B

3. Independent Safety Analysis

4. Review of TDD Volume II

The review for technical feasibility consists of an initial evaluation of the general concept of the experiment aimed at identifying unique safety issues. A detailed review of the experiment occurs when the experimenter submits TDD Volumes 1A and 1B. Volume 1A is the detailed description of the experiment and includes the safety analysis. Volume 1B is the fabrication requirements and includes the test drawings. The requirements for these documents are given the "FTR Users' Guide" (Reference 1).

After completion of the review of TDD1A and transmission of comments to the experimenter, a separate, complete safety analysis is independently performed at HEDL. After completion of the independent analysis, the results are compared with the experimenter's safety analysis and any differences must be reconciled. The final stage of the review is based on TDD-II which gives the as-built description of the experiment. Any differences between the design upon which the safety analysis was based and the as-built configuration are assessed for safety impact. If required, the safety analysis is revised to include the effects of non-conformances. A decision is then made on the safety acceptability of the experiment and any restrictions required for the operation of the test are established.

The scope of the Safety Analysis is divided into the following categories:

1. Experiment Safety Limits

2. Normal Operation

3. Off-Normal Events

4. Failure Analysis

5. HCDA

6. Seismic Analysis

7. Criticality and Test Handling Considerations

The scope of the safety analysis performed by HEDL and the experimenter is the same except that items 5 and 6 are performed by HEDL as a service to experimenters.

The experimenter is required to establish and justify safety limits for the test. He must then show that these limits would not be exceeded should any of the anticipated (upset) or unlikely (emergency) transients defined for the reactor occur. As a rule cladding integrity is a suitable safety limit for fueled experiments. Special tests such as a run-to-cladding breach test require an exception to this rule.

The normal operation evaluation of the test considers normal fuel behavior including restructuring, fission gas loading, cladding swelling and fuel-cladding interaction. The objective of this evaluation is to show that the test has a predictable chance of achieving its irradiation life objectives with sufficient margin relative to its cladding integrity limits that the test could withstand a prescribed number of off-normal events.

The off-normal evaluation subjects the experiment to the design transients defined for the reactor. Typically, an experiment intended for 300 FPD exposure is evaluated for withstanding 30 normal scrams, plant protection system terminated reactivity transients of 0.5, 3.4 and 24.3¢/sec, and loss of flow events such as loss of electrical power. The experimenter is also required to identify and analyze any transient that might be unique to the experiment (such as loss of bond in a sodium bonded fuel pin experiment).

The irradiation of an experiment involves the risk of a test failure since the fact that an experiment is being conducted implies that some performance unknowns exist. For this reason, a failure analysis is required for all experiments. The intent of the failure analysis is to demonstrate that the failure consequence would not propagate beyond the experiment boundary and that effects on the reactor and heat transport system would be within acceptable limits. Types of failures considered are stochastic pin failure, partial flow blockages, and unexpected failures induced by design transients.

The hypothetical core disruptive accident has been extensively analyzed for the FFTF core (Reference 2). The intent of the HCDA analysis of the experiment is to demonstrate that the experiment does not increase the energetics of the HCDA or its mechanical consequences beyond the envelope established for the FFTF driver core.

The FTR reactor has been analyzed for response to a design basis earthquake. An evaluation is required for all experiments to demonstrate that under DBE conditions the reactor would not sustain damage, by virtue of the presence of the experiment, which exceeds the envelope established for the reactor.

Criticality and Test handling review analysis requires the determination of the minimum critical configuration for experiment and any unique safety considerations that might be involved in the insertion or removal of the experiment from the reactor, and subsequent storage of the experiment.

CONCLUSIONS

A comprehensive safety evaluation of all experiments proposed for irradiation in FFTF is performed by the experimenter and independently by HEDL. The scope of the analysis includes evaluation of effects of reactor design transients and a failure analysis. The objective of the safety evaluation is accommodation of experiments with an appropriate level of protection for the reactor plant and the plant environs.

References:

1. H. A. Taylor, Users' Guide for Irradiation of Experiments in FFTF. HEDL-MG-22 Rev. 2, May 1978.

2. FFTF Final Safety Analysis Report, HEDL-TI-75001, December 1975.